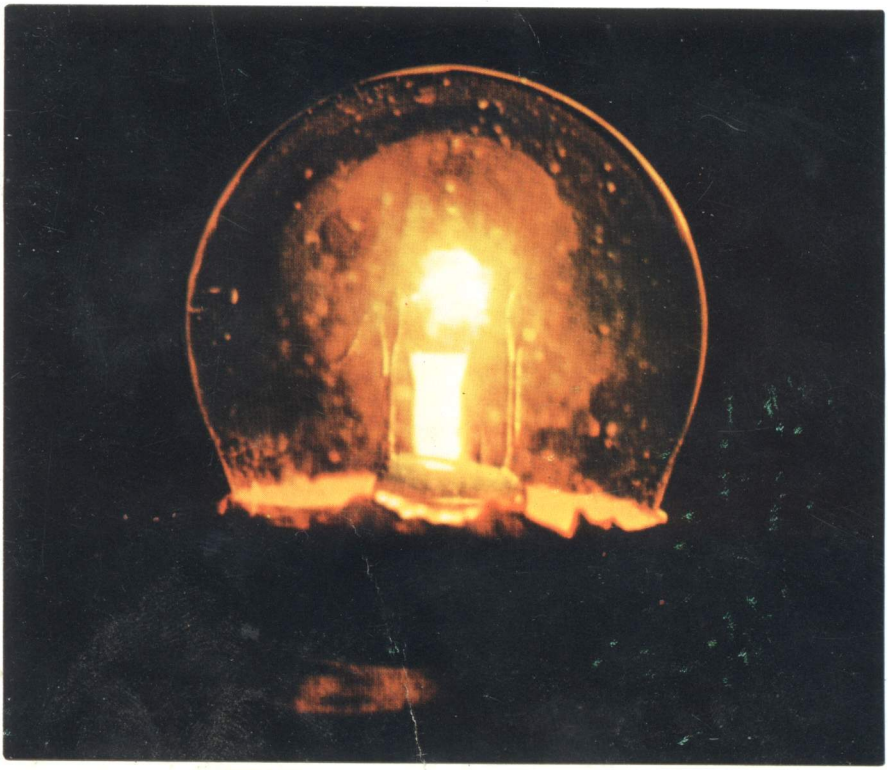
thomas salter toys + sports

Instruction Manual



Introduction

Magnetism and Electricity have always excited the curious and still do engage the enquiring mind. Both phenomena were known to the ancient Greeks who used a piece of magnetite, a magnetic oxide of iron found in Asia Minor, as a lode stone or compass for navigation. The Greeks also discovered that a piece of amber could be electrically charged by rubbing with silk.

Little development is recorded until the 17th century when Gilbert, a physician at the court of Queen Elizabeth I, experimented with magnetism and studied the magnetic field of the earth.

Electricity owes a great deal to Galvani and the 19th century experimenters like Oersted who discovered the magnetic field produced by a wire carrying an electric current.

Perhaps the greatest name in electrical science is that of Michael Faraday, whose work on electro magnetic induction led up to the modern electric motor, dynamo and transformer and to the growth of a technological society.

The following general instructions should be carefully read and followed. They will serve to increase your enjoyment in using this set.

General Instructions

This manual covers the experiments possible with the range of four Electrical Laboratories. The same manual is included with each set. So that you know which experiments you can do with your Lab, the manual is divided into four Sections so that with Lab 1 you can carry out the Experiments in Section 1. With Lab 2 you can carry out the experiments in Sections 1 and 2. With Lab 3 you can carry out the experiments in Sections 1, 2, and 3. With Lab 4 you can carry out the experiments in Sections 1, 2, 3, and 4.

Most experiments involve a procedure, some observation and then a deduction on your part. In simple terms you are asked to find out something. This is what makes all science so interesting since it is similar to unravelling the threads of a detective story with you as the detective. All the main materials and equipment required to carry out the experiments are supplied with your Lab but you will require to obtain simple household articles such as glue and string.

The expected results of experiments are printed at the end of each Section of the Manual.

Try the experiment before you check the result.

You must **always** read the instructions and make sure they are carefully carried out. All equipment supplied in your Lab is perfectly safe.

The following instructions should be carried out at all times:-

1 Magnets lose their magnetism if they are roughly handled. Take great care not to drop them otherwise they are liable to break.
2 Always use the Ratings of apparatus specified in the experiment e.g. do not use a 3 volt cell across 1.5 volt bulb.
3 Electrical experiments often fail due to faulty connections. Make sure all insulation is properly stripped and screw contacts are clean and tight.
4 Crocodile Clips are powerfully sprung so be careful not to pinch yourself with them.
5 Never taste or allow to be tasted any chemical contained in your Lab. Keep your fingers away from your face when using chemicals.
6 **Do not Tamper with the Main Electricity Supply.**
7 Before dismantling the apparatus set up for an experiment always read the next experiment first as you may require to use the same apparatus.
8 When using magnets remove your wrist watch. Do not place your magnets near clocks or electrical apparatus in your home.
9 Clean all apparatus after use.

When you have worked through the series of experiments in your Lab you should have a good working knowledge of the principles of Magnetism and Electricity. We hope that this knowledge will stimulate you to go on and learn more.

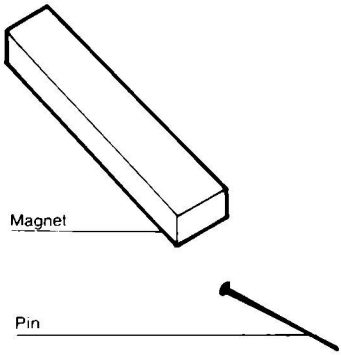
If you have any comments on our Electrical Lab Sets, please write to

Thomas Salter Ltd/Glenrothes/Fife/Scotland

Section **Experiments in this section can be carried out with Electrical Lab 1.**

1

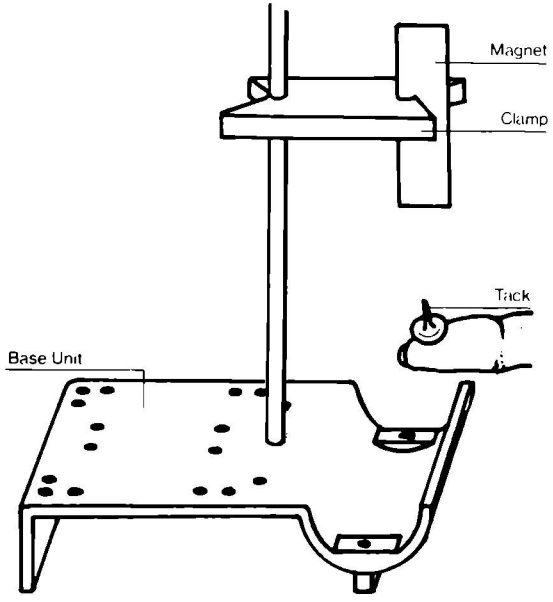
1 Approach a number of small objects such as a pin, nail, piece of rubber, cork, glass, etc. with the end of the magnet and record your observations in the table.



Attracted	Not Attracted

2 Remove the cap from the test tube containing the iron filings. Place the magnet on a piece of paper and pour the iron filings onto magnet. Lift the magnet from the paper and sketch what you see. Where do you think the magnetism resides in a bar magnet? Use a soft cloth to remove the iron filings from the magnet onto the paper. Fold the paper down the middle and return the iron filings into the test tube, making sure not to lose any.

3 Place the base unit flat on a table top and insert the plastic rod into the large hole on the base unit. Push the magnet into one fish tail of the clamp and slide the other end onto the plastic rod. (See diagram). Approach one pole of the magnet with a tack vertically from below, do it slowly until the tack 'flies' to the pole. How far from the magnet does this occur?



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4 Repeat experiment 3 but this time use a light panel pin. How far away is it before it flies? What does this teach us?

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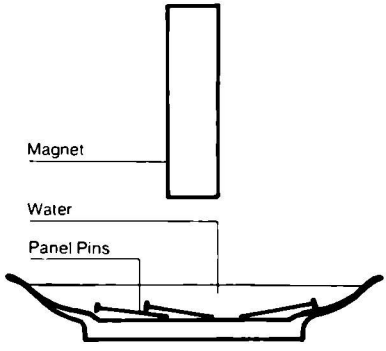
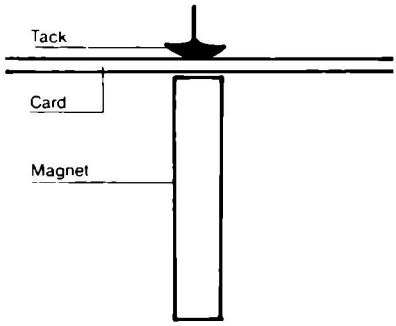
5 Place several panel pins in a saucer of water. Lower the pole of the magnet towards the water surface. What happens?



6 Place the tack on a piece of card and try to manipulate the tack by moving the magnet round under the card.



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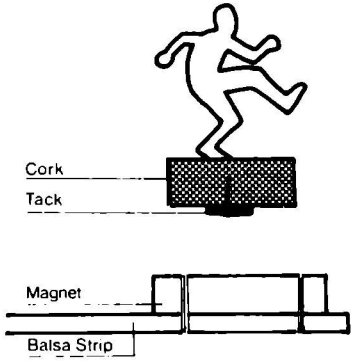
7 To construct a magnetic soccer game, cut two figures out of some thin card and colour it with crayons. Make a base from a piece of cork. (Do not cut the corks supplied as they will be required later).
Glue the figures to the cork bases. Push a tack into the base of the cork. Fix a bar magnet onto the end of a piece of wood. Place the figures on a thin table top and by manipulating the magnets under the table you can make your players move and 'kick' a marble or table tennis ball.



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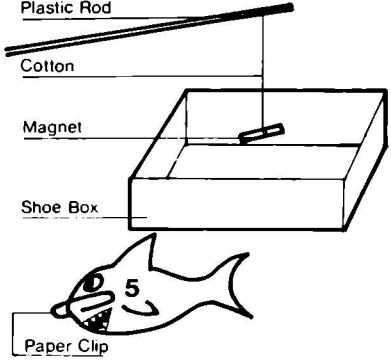
8 Another game you can play with magnets is a simple fishing game. Cut out fish shapes from a piece of card, colour and number them. Push a paper clip into the fish just above the mouth. Tie one end of a piece of thread to a magnet and the other end to a piece of wood or plastic rod. Place the fish in a box. You can then play with your friends taking it in turns to fish and see who can make the highest score. If this game is too young for you it may be possible to amuse younger children who perhaps live with with you or visit you.



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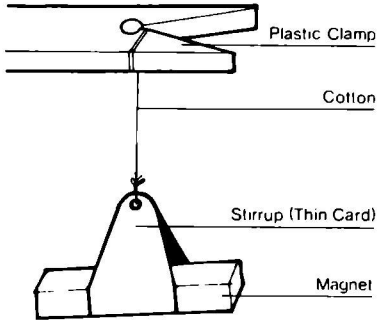
9 Set up the plastic rod, clamp and base as in Experiment 3. Make a small stirrup from a piece of thin card. Suspend a bar magnet as shown in diagram. Allow the magnet to come to rest and note its direction.



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10 Displace the magnet from its rest position and repeat Experiment 9. **Note the magnet's Direction.**

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11 After completing Experiment 10 make a chalk mark on the end of the magnet which points north. Displace it and observe.

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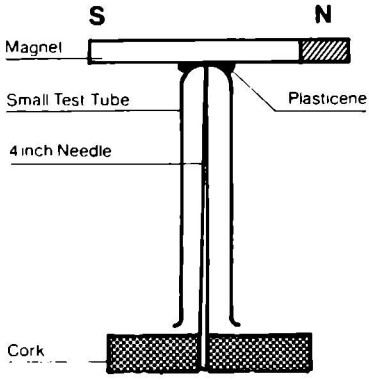
12 Now identify and mark the north pole of the other rectangular magnet in your set.

13 To construct a simple compass, set up the experiment as shown in diagram. A circle of card marked into 30° sections may be pushed over the needle above the cork base.



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14 The simple compass constructed in experiment 13 can now be used to estimate the directions of neighbourhood features such as hills, church spires, etc.

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15 Using the simple compass carry out the following instructions using the other magnet in your set.

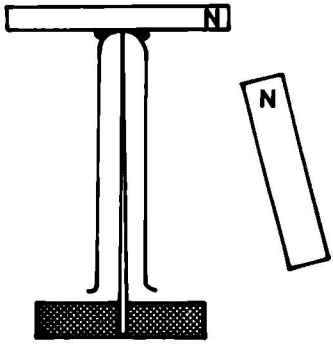
A Approach its north pole

B Approach the south pole of the compass magnet by the the south pole of the other magnet.

C Approach the north pole of the compass magnet by the south pole of the other magnet.

D Approach the south pole of the compass magnet with the north pole of the other magnet.

Write down what you observe in A, B, C and D and try to make a general statement about attraction and repulsion.



16 Still using your simple compass you should be able to find out if various objects such as scissors or a knife blade are magnetised. Bring one end of the knife or scissors to each pole of your compass in turn. If the object you are using is magnetised it must have two poles, one of which will produce repulsion of the like pole of the compass.

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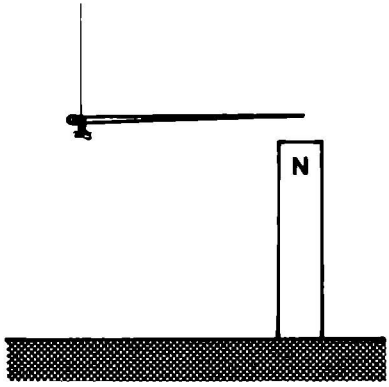
17 Magnetise one of the small sewing needles in your set and suspend it vertically on a piece of thread above the magnet. See diagram. Now lower the thread gently and try to float the needle as shown in diagram. If the needle does not float try using the south pole of the magnet.



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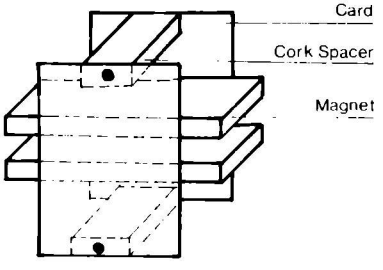
18 How to construct a magnetic boat. Cut a small piece of a drinking straw and slit along its length. Seal both ends with glue to make a boat shape as shown in the diagram. Place a panel pin inside the boat. Your boat is now ready to float on the surface of water in a bowl. You can now control your boat by holding a magnet close to it.

19 In this experiment you can float a magnet in air. The diagram explains the construction of the equipment required. The cork spacers must be cut slightly wider than the magnets so that the magnets are just free to move.
First place the bottom magnet in position and then place the second magnet above the first magnet so that like poles are above one another. Release hold of the second magnet so that it floats in the air. You will have to experiment with the distance between the magnets to carry out this experiment successfully.



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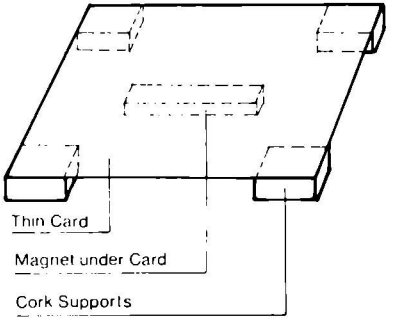
20 To plot a magnetic field around a bar magnet. Cut a piece of thin card approximately 8" x 6" place the card on four cork supports with the magnet placed under the card. See diagram. Now sprinkle iron filings very lightly over the card (an old pepper pot would be useful for sprinkling the filings). While sprinkling the filings hold the card firmly by pressing down on one corner. Gently tap the card with another finger until a clearly discernible pattern is produced. Sketch your results.



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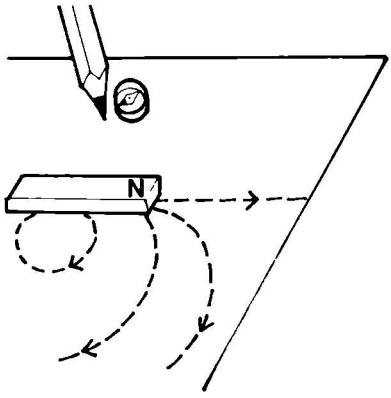
21 Repeat experiment 20 using two bar magnets in line with
A North poles about $\frac{3}{4}$" apart. Sketch fields.
B South poles about $\frac{3}{4}$" apart. Sketch fields.
C A north and south pole about $\frac{3}{4}$" apart. Sketch fields

22 How to plot fields using a small plotting compass. Place a bar magnet in the centre of a sheet of writing paper and place the small plotting compass near one edge of the paper. Mark a pencil dot near the north pole of the compass needle and move it forward until its pivot is over the dot. Proceed until a line of dots is obtained which may be joined up to give a continuous line of magnetic force. The direction of the line may be arrowed in. It is the direction in which the compass points along the line.



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23 Now fill in arrows on your sketches obtained by the iron filings method in experiments 20 and 21.

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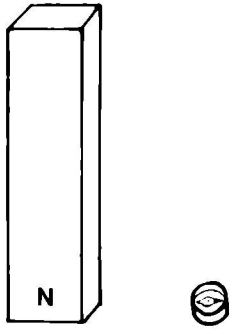
24 Plot the field surrounding the north pole of a vertically standing magnet using the method of experiment 22.



25 Complete the following statements by inserting the missing words:—

1 A line of magnetic force is the path along which an isolated pole would travel if free to do so.
2 It commences on a pole (or at) and ends on a pole (or at)
3 The lines are densely packed near of a magnet i.e. where the field is very
4 The lines do cross each other.

In the next experiment you will make a magnet from a piece of steel strip. Before doing so you must test the strip to find out If it is already magnetised. To do this dip the strip into iron filings and remove. If any filings cling to the strip it will be shown to be magnetised and must therefore be de-magnetised. This can be done by first heating to redness. And then allowing to cool.

YOU MUST ASK AN ADULT TO DO THIS FOR YOU.

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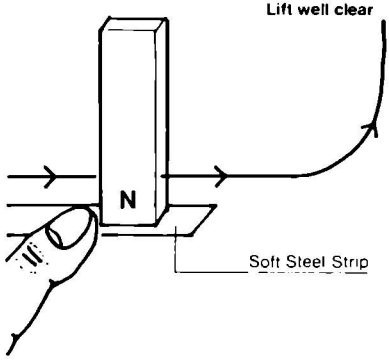
26 To make your own magnet, stroke a piece of soft steel strip three times as shown in diagram. Dip the steel strip into the iron filings to test its strength.



27 Give the strip used in the previous experiment three more strokes with the same pole in the same direction as before and dip in iron filings. What happens?

---

28 Continue stroking the strip. How strong can you make your magnetised strip?

---

29 Test the polarity of your strip using the compass needle (repulsion test).

---

30 Repeat experiment 29 but this time change the direction of stroking. Test the polarity.

---

31 Repeat experiment 30 using the south pole of the magnet. Test the polarity.

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32 Repeat experiment 31 but this time change the direction of stroking.

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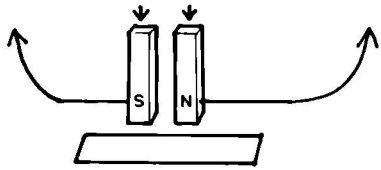
33 Another method of magnetising a steel strip is by divided touch. Use two magnets and stroke as shown in diagram. Test the polarity.



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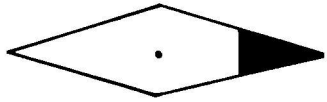
34 Repeat experiment 33 but this time use two north poles of the stroking magnet. What do you think will happen?

35 Construct an improved compass needle. Cut a piece of soft steel strip 2" long as shown in diagram. Magnetize by stroking. Find and mark the north pole and mount on test tube and needle point as in experiment 13.



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36 What happens when you cut a magnet into pieces? Can a 'free magnetic pole' be obtained. Magnetise a 4" long steel strip and determine polarity. Mark north pole and cut in two. Determine polarity of both ends and mark north poles.

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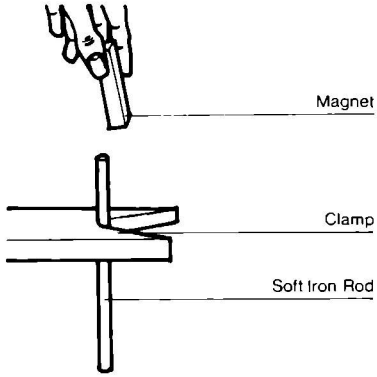
37 Cut the two 2" lengths from the previous experiment in halves to obtain 4 pieces each 1" long. Have you got free poles this time?

---

38 Clamp a soft iron rod vertically and support it on the base unit as shown in diagram. You will have to wrap a piece of card around the iron rod so that it is securely held in the clamp. Hold the bar magnet above, close to but not touching the rod, so that the rod is in the field of magnet. Bring up the iron filings in test tube and immerse the lower end of the soft iron rod. Remove the container. What do you see? Now remove the bar magnet. What happens now?



39 Repeat experiment 38 using the hard steel rod in place of the soft iron.

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40 Complete the following sentences:

1 Soft iron makes a magnet but a one.
2 Steel makes a magnet but a one.

---

41 Repeat experiment 38 and test the polarity of the induced magnet using a plotting compass (repulsion test)

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42 Repeat experiment 41 but reverse the polarity of the inducing magnet.

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43 What happens inside a bar when magnetised? This experiment may help you find out.
Take a test tube of iron filings and stroke it with a bar magnet using the method of single touch. What do you observe?

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44 Repeat experiment 43. After magnetising the iron filings do not shake the test tube. Approach each end of the test tube with a plotting compass needle. What do you observe?

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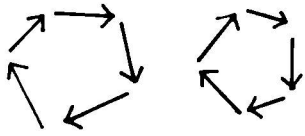
45 Shake the magnetised iron filings in the test tube and test for polarity.

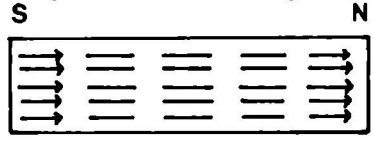
Ewing's Magnetic Theory

A man called Ewing suggested that the molecules of magnetic materials may themselves be minute magnets with two poles represented in the diagram by a small arrow →. In an unmagnetised bar they form closed circuits with north and south poles close together and cancelling out each other's effect. When a bar is magnetised by stroking or other methods the molecular magnets become aligned in the field direction

→ → → →

The rows of molecular magnets produce a row of north and south poles at either end. Inside the material north and south poles cancel out each others effect. This explains end-polarity of a bar magnet. Does Ewing's theory explain your experiments on stroking, cutting up, magnetic induction, etc? Bear it in mind when you carry out further investigations.





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46 To study demagnetising of a bar. First magnetise a piece of steel strip by the single touch method until you have a strongly magnetised strip. Test by dipping in iron filings. Wipe clean but save the filings. Now hammer the strip vigorously and re-test by dipping in filings. Is the strip still magnetised?

---

47 Remagnetise the strip until it will once again pick up lots of filings. Wipe clean and heat the strip to redness and allow to cool. **ASK AN ADULT TO DO THIS FOR YOU.** Redip the cooled strip in filings. What do you notice?

---

48 Does Ewing's theory explain experiments 46 and 47.

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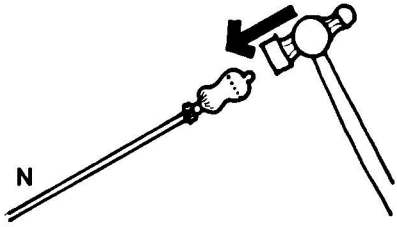
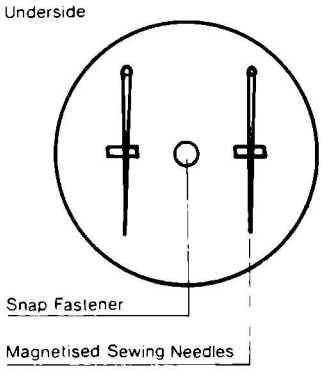
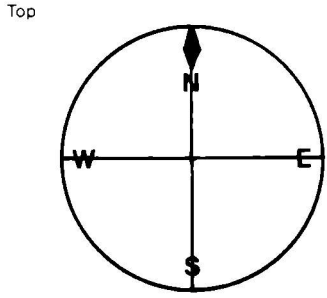
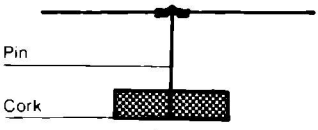
49 A poker may be magnetised using the earth's magnetic field Hold a poker pointing north and slightly downwards towards the ground. Hammer the end several times. See diagram. Test for polarity.



50 How to construct a model mariner's compass. Cut a piece of thin card into a circle 3" in diameter. Cut a hole in the centre and fit the snap fastner supplied. Magnetise two needles and fix to card with a small piece of tape. Make sure that the needles are parallel to each other and with similar poles pointing in the same direction. See diagram. Mark the reverse side of the card as shown in diagram. The N and S line must be marked in the same direction as the N and S poles of the needles. Now balance the card as shown in diagram. A small piece of plasticine stuck to the underside of the snap fastner may be found useful.

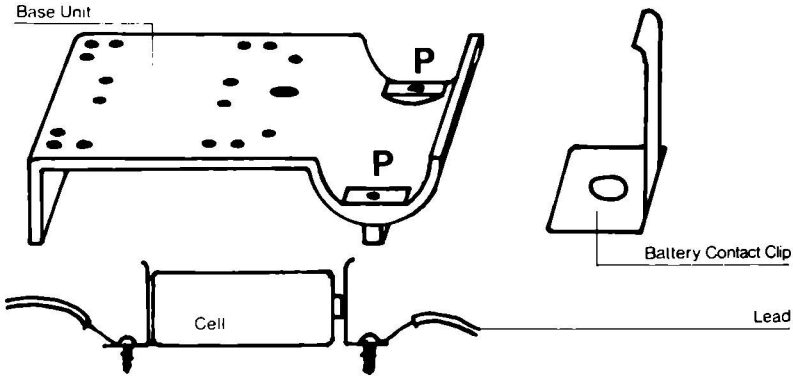




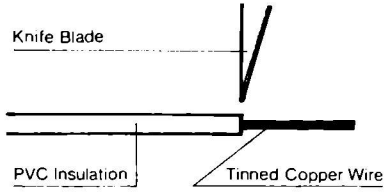


The next series of experiments is all about Electrical Circuits.

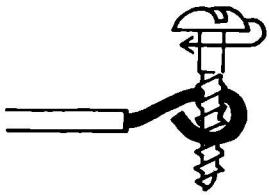
51 The base unit supplied with your set has been designed to enable you to carry out experiments using various other pieces of equipment supplied.
The source of energy used in the following experiments is a cell (commonly referred to as a battery).
To set up the base unit secure two brass contact clips at the positions marked P in diagram. The clips are secured by self-tapping screws. Before tightening the screws fit a 24" length of PVC covered wire to each screw terminal.
Read experiments 52 and 53 before fitting the wire. When the wire has been fitted place the battery in position between the terminals. Be sure that the contact clips press strongly against each end of the cell. If this does not happen remove the battery and bend each clip slightly inwards.



52 To prepare an electric lead take a length of PVC connecting wire and press the edge of a sharp knife about $\frac{5}{8}$" from the end. Rotate the wire and cut through the plastic covering which can then be eased away from the wire to leave it bared. See diagram.



53 To secure a lead under a screw terminal, turn the bare end of the lead in a clockwise direction when looking down on it. Place it in position over the hole and insert the screw as shown in the diagram. When the screw is rotated it will tend to tighten up the hook of wire around itself.



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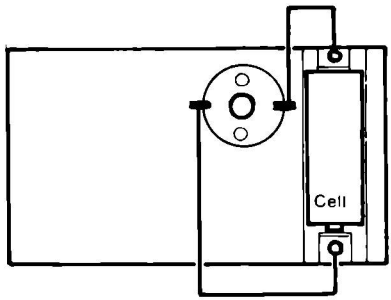
54 To set up a simple circuit. Connect up a cell and screw a bulb holder to a base unit as shown in diagram. Screw in a 1.5v bulb. What happens?



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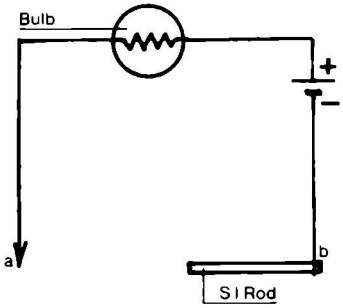
55 Set up experiment 54 but this time unscrew one of the leads from the bulb holder and see what happens.

---

56 Repeat experiment 54. Remove the battery. What occurs this time?

---

57 Does electricity flow through all solids? Connect up the circuit as shown in diagram. Touch bared end of lead onto the end of the soft iron rod and in this way complete the circuit. What results do you obtain? This diagram is called a schematic diagram and contains all the information required to set up a circuit. In future experiments we shall use schematic diagrams, introducing new symbols as they are required.



58 Repeat experiment 57 using a steel rod instead of a soft iron rod. What result do you obtain?

---

59 Repeat experiment 58 but this time use a glass rod. What do you see?

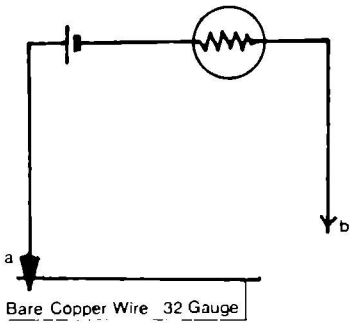
---

60 Repeat experiment 59 using any of the materials in your set or in your pocket. Tabulate the results.
Does air allow electricity to flow through it?

Material in Gap ab	Bulb	
	Lights	Does not light
S. I. Rod		
Steel		
Glass		

---

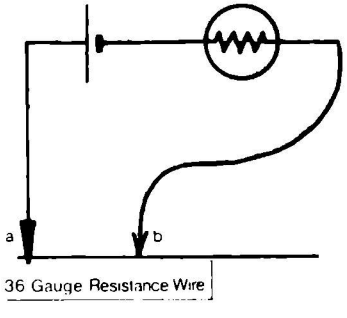
61 In this and the next three experiments which are about Electrical Conduction you will require the following wires from your set.
32 gauge bare copper wire
32 gauge resistance wire
36 gauge resistance wire
The smaller the gauge number the thicker the wire. Connect up the circuit as diagram. Clip one end 'A' of the copper wire into the crocodile clip and touch bare lead end 'B' to the other end of the copper wire so that it completes the circuit. What happens?



62 Repeat experiment 61 but this time use 32 gauge resistance wire. This wire is the same length and thickness as the copper wire therefore the only change is in the type of material used. What do you see when you complete the circuit?

63 This time use 36 gauge resistance wire instead of 32 gauge. The only change here is in the thickness since you have substituted a thinner wire. Complete the circuit as in experiment 62 and note the result.

64 Connect up the same circuit as Experiment 63. Touch the bare lead 'B' close to 'A' on resistance wire and slide it slowly to the right thus increasing the length of the resistance wire in the circuit. What do you notice?
NOTE: So far our experiments have shown that the factors affecting resistance (R) are the length (L) thickness (t) and the material of which the wire is made e.g., bare copper is a better conductor than an alloy resistance wire. If ↑ represents increasing and ↓ decreasing then our results may be expressed:
With t constant and L↑ then R↑
With L constant and t↑ then R↓
Is there any other factor which could affect the resistance of a wire?

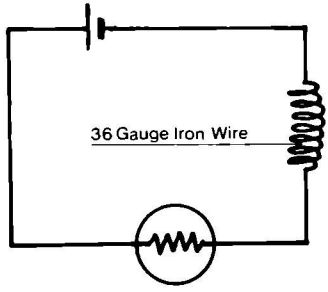


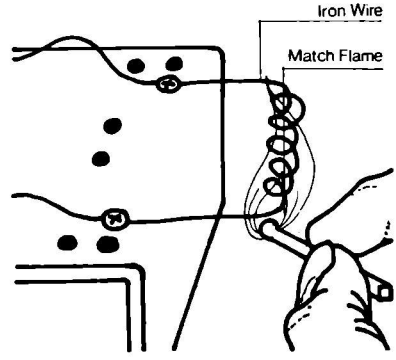
65

Does temperature affect the resistance of a wire? Wind a 6" length of iron wire around a thin pencil into a close coil leaving about 1" straight at each end. Screw ends to base with connecting wires as shown in diagram. Complete circuit as diagram. Note the bulb brightness. Now heat the coil of iron to redness with a match flame. (Be careful not to damage the plastic base unit). What happens to the bulb brightness? What do you conclude?

NOTE: The laws of resistance for a uniform conductor such as a wire are:

L↑ R↑, t↑ R↓, Temperature ↑ R↑.

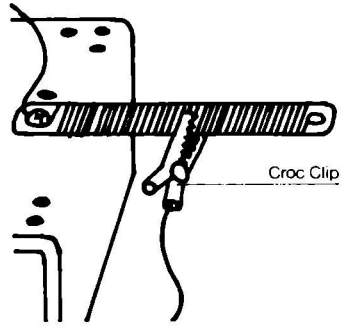


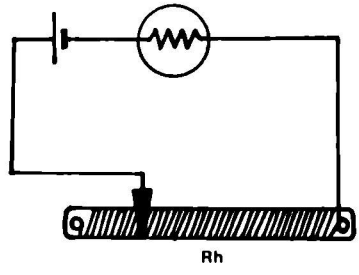


66

In this experiment you may study the Rheostat and find out how it works.

Screw the rheostat to the base unit with a screw and small washer and connecting lead as shown in diagram. Complete the circuit as diagram. Always make sure that the crocodile clip is firmly pressed to release it, otherwise you will damage the rheostat. You should now be able to experiment with the rheostat and see how it works. What conclusion do you reach?

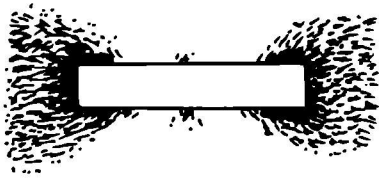




Section 1 Results

R1 Non metals are unattracted while only a few metals are strongly attracted. Metals which are strongly attracted are iron, nickel, cobalt and many alloys. These are called magnetic substances.

R2 The iron filings cling thickly to the ends of the magnet where magnetism appears to be concentrated. These regions are called Poles.



R3 The tack will fly when near the pole. Here the magnetic force is strong enough to lift it.

R4 The light pin flies further from the pole than the heavy tack. It requires less force to lift, therefore the magnetic force is weaker as we move away from the pole.

R5 The magnetic force acts through the water to attract the pins.

R6 Magnetic force acts through the card (a solid).
Experiments 1 to 6 show that a magnetic force acts through a solid, liquid or a gas. The space around a magnet in which magnetic forces may be detected we call a magnetic field.

R9 The magnet oscillates and comes to rest in approximately a North and South direction.

R10 Again the magnet comes to rest in a North-South direction.

R11 The marked end of the magnet again points north in the rest position. This north seeking pole is called the NORTH pole of the magnet. The opposite end is labelled the SOUTH pole of the magnet.

R15A The North pole of the compass magnet is repelled.

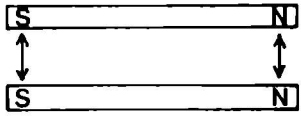
R15B The South pole of the compass magnet is repelled.

R15C The North pole is attracted by the South Pole.

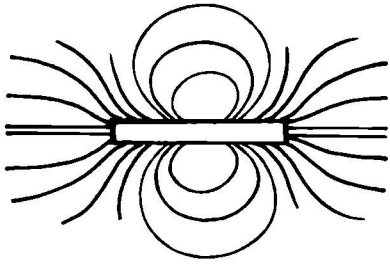
R15D The South pole is attracted by the North pole.
The Results of Experiment 15 lead to the statement, like poles repel, unlike poles attract.

R17 The needles will float as shown due to repulsion between like poles.

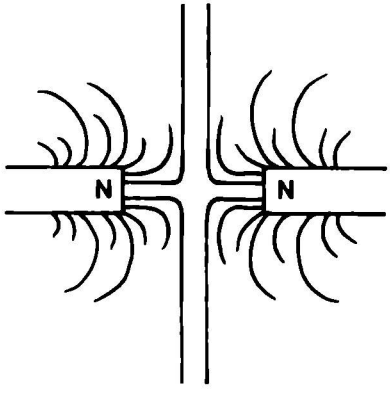
R19 The result is due to repulsion between like poles as shown in diagram.



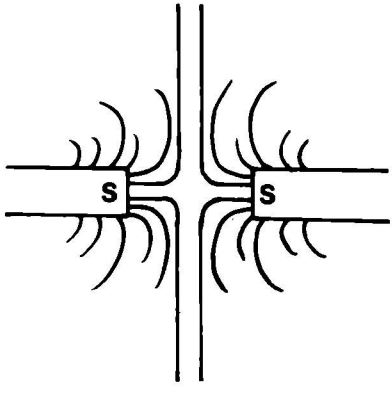
R20



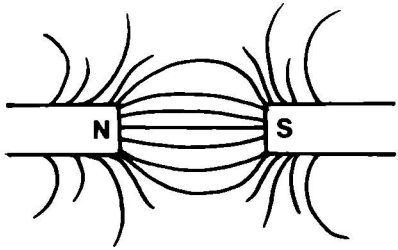
R21A



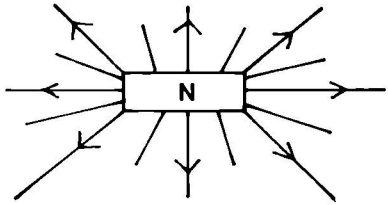
R21B



R21C



R24



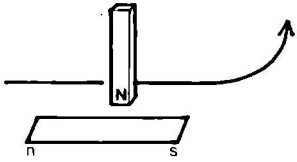
R25 1 North
2 North (infinity)—South (infinity)
3 Poles, strong
4 Not

R26 A few iron filings should stick to the bar showing it to be weakly magnetised.

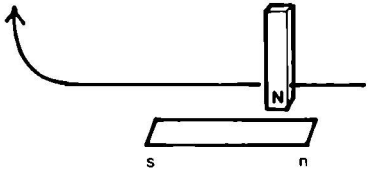
R27 More filings stick to the strip showing it to be more strongly magnetised.

R28 Repetition of the experiments show that the strip becomes more strongly magnetised up to a point where it is said to be 'saturated' with magnetism.

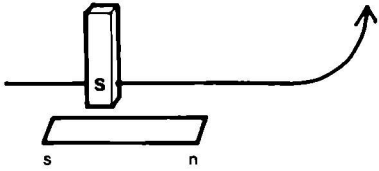
R29 Polarity is as shown in diagram.



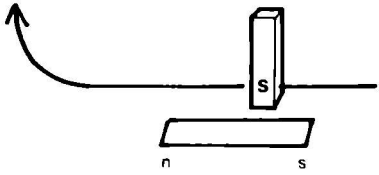
R30



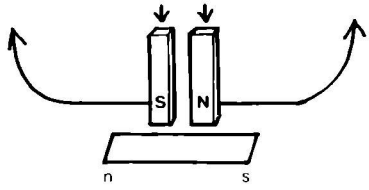
R31



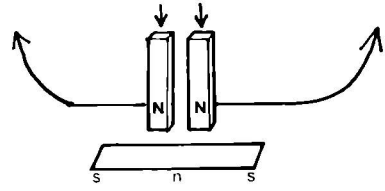
R32 The last few experiments use the method of single touch to make bar magnets. Reversing the poles of the stroking magnet or the direction of stroking will reverse the polarity of the strip.



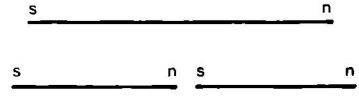
R33



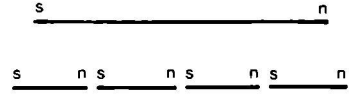
R34 The strip becomes magnetised as shown. It may really be thought of as two bar magnets with North poles stuck together.



R36 We get two magnets with polarities as shown.
The direction of magnetism is unchanged.



R37 You may keep trying but no one so far has succeeded in isolating a 'free' at a North or South Pole.

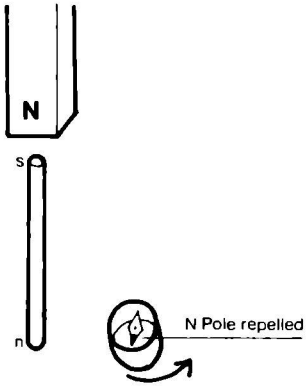


R38 The soft iron rod becomes magnetised by **Induction** in the field of the bar magnet. On removing the inducing magnet most of the iron filings drop off showing that soft iron is not very retentive of magnetism.

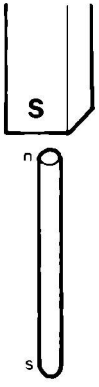
R39 Steel becomes less strongly magnetised by induction than soft iron but is more retentive on removal of the inducing field.

R40 1 Strong temporary
2 Weaker permanent

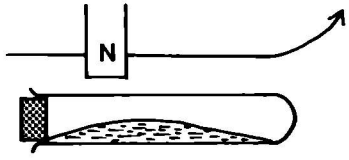
R41 Direction of magnetism in rod is the same as in a bar magnet.



R42 Again direction of magnetism in the rod is the same as in the bar magnet.



R43 The filings tend to align themselves in the direction of stroking.
NB If the effect is small try using both bar magnets side by side to increase the effect.



R44 The filings are magnetised like a rod with poles at its end.

R45 Magnetism has disappeared. Filings behave like an unmagnetised bar i.e., both ends of it attract both ends of the compass needle.

R46 The strip will lose most of it magnetism after hammering.

R47 Heating demagnetises the strip.

R48 Hammering and heating upset alignment of molecular magnets which reform close circuits. Bar is magnetised.

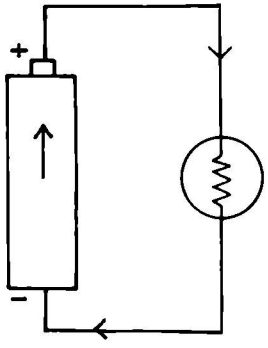
R49 The poker is found to be demagnetised. Ewing's theory suggests that hammering causes the molecules to oscillate out of closed circuit and reset in alignment in the earth's field.

R54 If your connections are well made the bulb lights up brightly.

R55 Bulb goes out.

R56 Bulb goes out.

Experiments 54-56 show that we require a source of energy (the cell) and a complete or unbroken circuit to light the lamp. Early experimenters assumed that something called electricity flowed around a complete circuit. They assumed that the electric current flowed from one pole positive (marked +). Round the circuit to the negative pole (marked –). A cell is often represented by |I. The long thin stroke stands for positive (+) and the short thick stroke for negative (–) pole of the cell.



R57 Bulb lights. Electricity flows through soft iron to complete circuit.

R58 Bulb Lights, therefore electricity flows through steel.

R59 Bulb fails to light. Electricity does not flow through glass.

R60 Metals or carbon are good conductors of electricity. Other non metals are poor conductors. Some are so poor that they are used as insulators i.e., to prevent electrical flow altogether. Air is an insulator.

R61 The bulb lights because the circuit is complete and the copper wire in gap A-B is a good conductor of electricity.

R62 Bulb lights less brightly illustrating that the current flow is reduced by the resistance wire therefore resisting the flow of electricity to some extent.

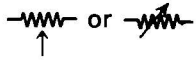
R63 Bulb still lights but less brightly than in previous experiment. Hence current is still smaller and thinner wire has more resistance

to current flow than has a thick wire of the same material and length.

R64 The bulb gets dimmer as length of wire in circuit is increased. Therefore the resistance of a wire increases as the wire is made longer.

R65 Bulb gets dimmer, therefore current has decreased hence resistance of wire has increased when heated, if temperature ↑ then R↑.

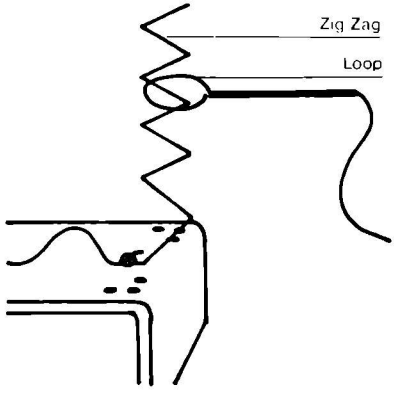
R66 Moving the croc contact (carefully) will change the length of resistance wire in the circuit and thus change the current.
A Rheostat is a variable resistance and its symbol may be

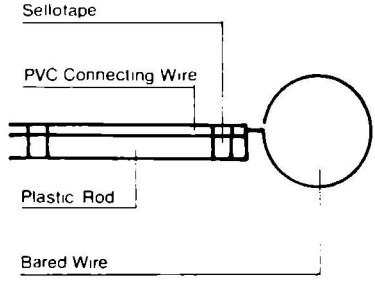


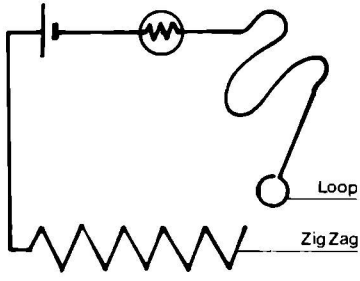
Experiments in this and previous section can be carried out with Electrical Lab 2.

67

The Zig Zag wire in your set can be used in a game of skill for all the family.
Screw the Zig Zag wire to the base unit as diagram. Bare 4" from a 24" length of PVC wire and form this end into a loop. Tape the PVC wire with the loop to the plastic rod in your set. See diagram. Complete the circuit as diagram. The idea of the game is to move the loop from top to bottom of the Zig Zag and back again without making contact and thereby flashing the bulb.







68 How does a switch work? Unscrew the cover from the switch to expose the brass contacts and the base fixing holes. You will not require the cover again in this experiment as we wish to study how the mechanism works. **(NB Never do this with MAINS SWITCHES).**

Fix the switch to the base unit with two screws (do not overtighten). Fit a PVC connecting wire to each brass contact by inserting the bared end of the wire and tightening the screw sufficiently to make good electrical contact.
How does the switch work?

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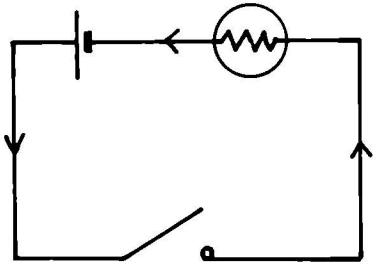
69 To examine the operation of a switch in a circuit connect up as in diagram. Leave the switch cover off so that the mechanism may be seen.
The symbol for a switch in a schematic diagram is



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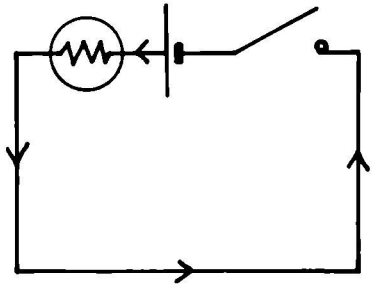
70 Connect up the circuit in diagram. What change have you made? Has bulb brightness changed? Has current strength changed?



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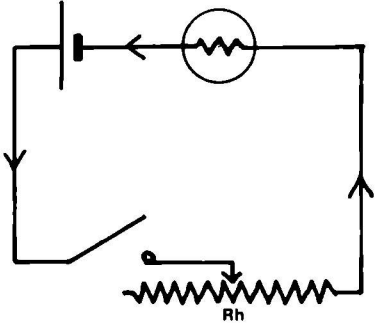
71 Using the switch, bulb and Rheostat set up the circuit shown in the diagram. Switch on and adjust the Rheostat to give a reasonably bright bulb, then leave rheostat set. Note brightness.



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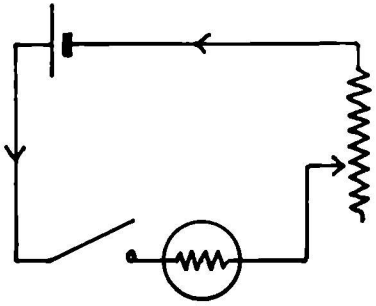
72 Using the same items as in the previous experiment connect up as diagram. Note the bulb brightness. Compare with experiment 71.



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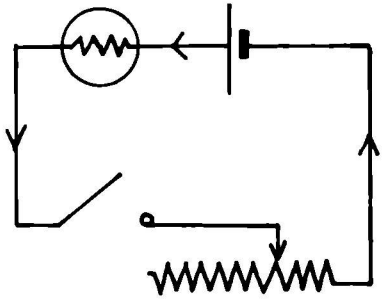
73 Rewire as diagram. Switch on and note bulb brightness.



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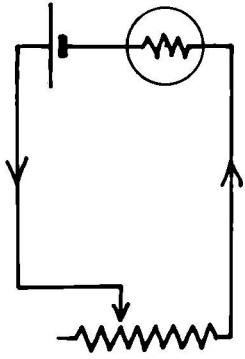
74 **The Short Circuit**

Wire the circuit as in diagram and adjust the rheostat to dim bulb. The problem is how to insert the switch in such a way that the bulb brightness is restored.

Clue-a switch blade is a good conductor.



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75 **Electromagnetism**

How to construct a solenoid. You will require the 5 yard length 22 gauge enamelled copper wire and the $2\frac{3}{8}$" long x 3/16" diameter soft iron core. Clamp one end of the core into the plastic clamp and secure vertically on base unit using the plastic rod. Scrape the enamel from about $\frac{1}{2}$" of each end of wire so as to ensure a good electrical connection. The enamel is an insulating coating so do not scratch it off elsewhere. Now close wind one layer of wire on the core as neatly as possible. Do not cut the remaining length of wire as the full 5 yard length will be required for a later experiment.

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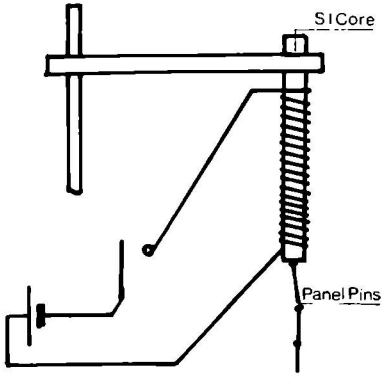
76 To study the energised solenoid connect the circuit as in diagram. Complete circuit by closing the switch. Bring up a panel pin to core as shown. What happens? Do not leave current switched on for very long otherwise your battery will run down quickly.



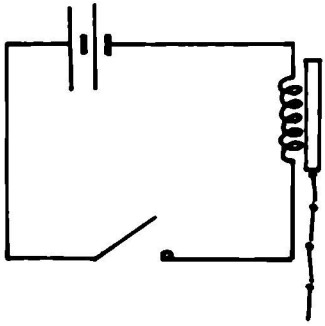
77 Repeat experiment 76 but this time add panel pins until no more are supported. Count the number as a measure of the magnetic strength of the solenoid.

---

78 Disconnect the circuit and remove the solenoid from the clamp. Add another layer of turns on the solenoid keeping the windings going in the same direction. Repeat experiment 77 and count the number of pins supported.

---

79 Complete the circuit as shown in diagram this time using two cells. It will be necessary to use both base units in your set with a cell fitted to each unit. Connect the cells in series i.e. positive (+) to negative (−) (This increases the current strength in circuit). Estimate the strength of magnetism produced by counting the number of pins that can be supported.



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80 Set up the circuit as in experiment 79. Determine and note the polarity of the solenoid using a compass needle.

---

81 Reverse the solenoid connections or both cells so as to reverse the current direction in circuit. Now redetermine the polarity of the solenoid.

The Vibrator Unit

To set up the vibrator unit you will require to identify various pieces of equipment in your set. These are as follows:-

82

1 The Vibrator Spring Assembly (A) as shown in diagram. This is a length of spring steel riveted to a bracket with a soft iron stud attached to the spring steel.

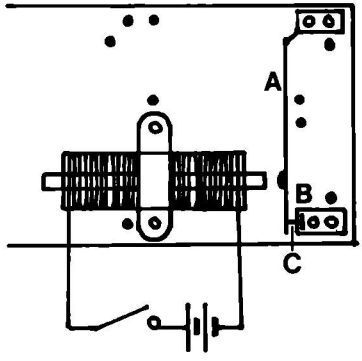
2 Right Angled bracket (B). This bracket has two large holes for fixing to the base unit and also a small hole to accept the small brass screw.

3 Brass Screw (C).

4 Soft iron rod as used in experiment 75.

5. Enamelled wire. You will require to use the 5 yard length which you will find in the large test tube.

Carefully wind the solenoid as neatly as you can layer upon layer leaving about 4" leads at each end, from which about $\frac{1}{2}$" of enamel has already been scraped. Hold the windings in position with a small piece of sellotape and slide into clip. It should be a push fit, but if too loose it can be packed with a layer of paper or card over the windings. Screw clip into position as shown. The core should be 3 or 4mm away from the stud on the vibrator. Connect up circuit as diagram using two cells in series. Switch on current. Now switch off. Note what happens.



83

To make the vibrator work, first study the spring vibrator contacts, etc., and try to reason out a method of making it vibrate continually.

R68 With the blade open an air gap exists across the terminals and so no current flows. With the blade closed a good conductor (brass) connects the terminals and a current will flow in a circuit.

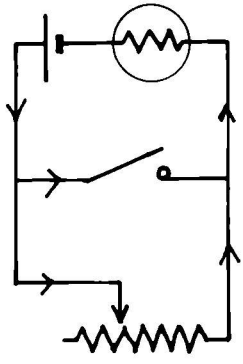
R69 As predicted in experiment 68, the blade makes (completes) or breaks the circuit so starting or stopping a current flow.

R70 The switch and bulb are interchanged in position. Bulb brightness remains the same. Current strength is the same at both points in the circuit. Note we are using the bulb as a current detector and its brightness as a measure of current strength.

R72 Bulb remains at same brightness. Hence current strength is the same at this point of circuit as at previous one.

R73 The brightness is the same as experiments 71 and 72. Hence the current strength is the same at all points of the circuit. We call this a series circuit.

R74 The switch may be inserted so that current takes line of least resistance through it, rather than through high resistance path of rheostat.



R76 When an electric current flows round a solenoid it is said to be energised and becomes a magnet.
When the current ceases, the magnetism vanishes.

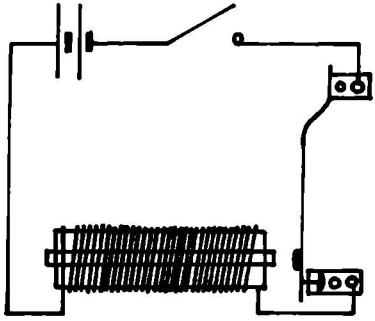
R78 More pins can be supported therefore the magnetism is increased. Piling on turns of wire increases magnetic strength. Now pile on as many turns of wire as possible to make a really powerful electro magnet.

R79 More tacks can be supported showing that magnetism is increased if current strength increases.

R81 Reversing current reverses the magnetic polarity of the solenoid.

R82 The vibrator spring is attracted forward to the core as you expected. When current ceases to flow the spring returns.

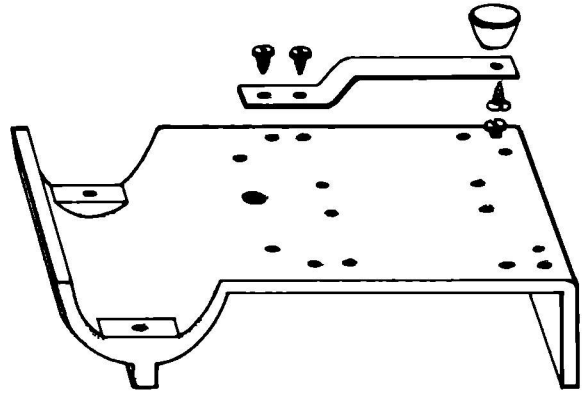
R83 Did you work this one out yourself? It is easily seen how it works.
To make it work properly you must experiment with,
a Distance of core from stud on vibrator.
b Adjust make and break screw.
c a $4\frac{1}{2}$ volt battery will make it buzz even better.
This is the principle of the morse buzzer and electric bell.

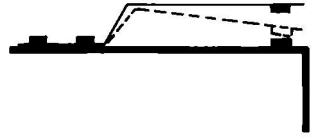


Section **Experiments in this section and previous sections can be carried out with Electrical Lab 3**

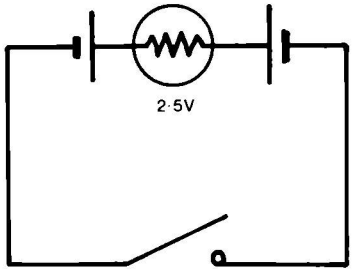
3

84 In previous experiments you will have used the plastic toggle switch contained in your set. In this and some of the following experiments you will require to use a key switch. To make up the key switch identify the parts shown in the diagram. Attach the plastic knob to the key plate by one of the two small screws supplied. Attach the key plate to the base unit with two screws. The second small screw should now be screwed to the base unit so that it is in position directly beneath the screw which fastens the plastic knob to the key plate. To wire up the switch into the circuit connect one lead to one of the two screws securing the key plate to the base unit and the other lead to the small screw fixed to the base unit. To operate the switch, press the plastic knob downwards and thereby complete the electrical circuit. Connect a single cell, 1.5v bulb in holder and Key switch in circuit on a base unit. Switch on and note brightness of bulb. Now exchange bulb for one with 2.5v rating (identified by a red spot) and again note brightness.





85 Connect up the circuit as diagram and see what happens.



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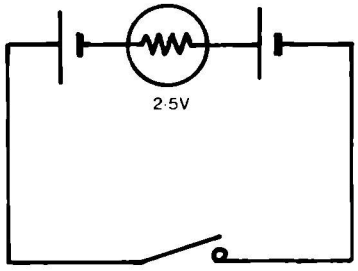
86 Try again with two cells but this time connect as diagram. What happens?



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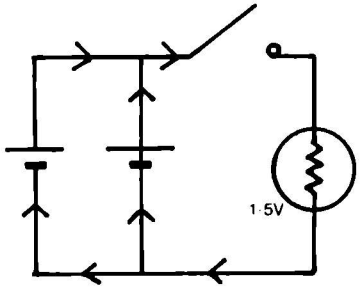
87 Connect two cells in parallel as shown in diagram. Switch on and note brightness. Compare brightness with single cell circuit.



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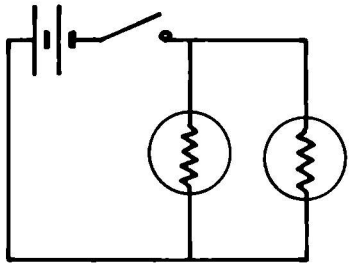
88 Can you include a second switch in the circuit of experiment 87 so as to switch on either or both cells when required.

89 a) Connect up two base units, two cells, two bulbs and a switch in series. Switch on and note brightness.
b) Using the same parts as in (a) connect up the circuit in parallel as in diagram. Switch on and then unscrew each bulb in turn. What happens?



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90 Repeat experiment 89 but this time include a second switch so that one or two bulbs may be operated.

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91 Use the circuit in experiment 90 to wire up two lights in a toy building such as a fort or a doll's house.

We will now have another look at short circuits. Remember this is the introduction of a low resistance conductor in such a way that a current will by-pass a larger resistance path. First, however, let us study the heating effect of an electric current.

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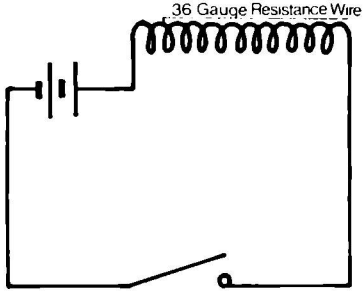
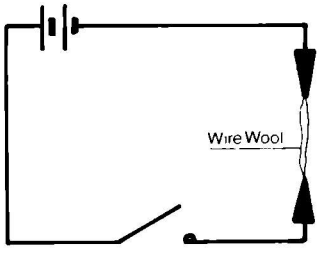
92 Set up the circuit shown in the diagram. Switch on and hold the resistance wire lightly between your finger and thumb. What do you feel happening? Switch off quickly to protect the battery.



93 Obtain a small piece of FINE wire wool. Tease out the wire wool and by using two crocodile clips set up the circuit in the diagram. **Be sure to place the wire wool and croc. clips in an old saucer before switching on.** For this experiment to work well it is important to use new batteries and a fine grade wire wool.



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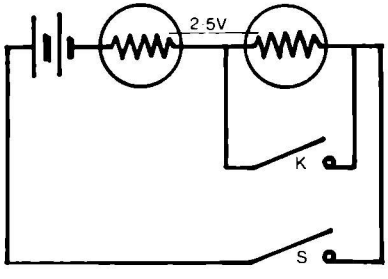
94 Another experiment on the short circuit is shown inthe diagram. Close Switch S only and note the bulb brightness. Now close Switch K as well to short out one bulb. What do you notice?



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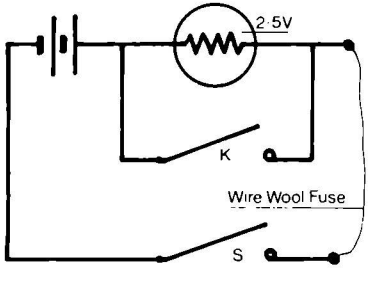
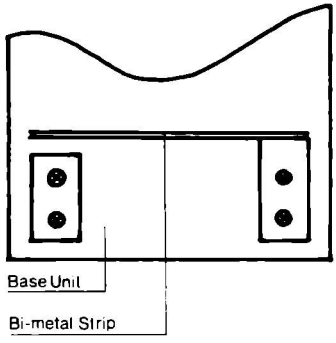
95 To understand the use of a fuse in a domestic circuit, set up the circuit in the diagram using a piece of fine wire wool as in experiment 102. First close switch S and then close switch K so as to short out the bulb.



96 So far, you have experimented with various circuits which includes an 'on' and 'off' switch operated by hand. We can now experiment using a different type of switch. You will find in your set a Bi-metal strip riveted to a bracket. This unit is easily recognised by the word TELCON which appears on the strip. You will also require one of the two small brackets in your set. For this experiment use the bracket which does not have the small threaded hole.
Screw the bi-metal strip and bracket to the base unit and then screw bracket to the base unit. The diagram illustrates the position of both items. Now warm the bi-metal strip with a match flame and observe what happens.



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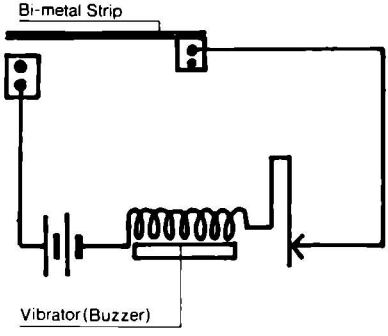
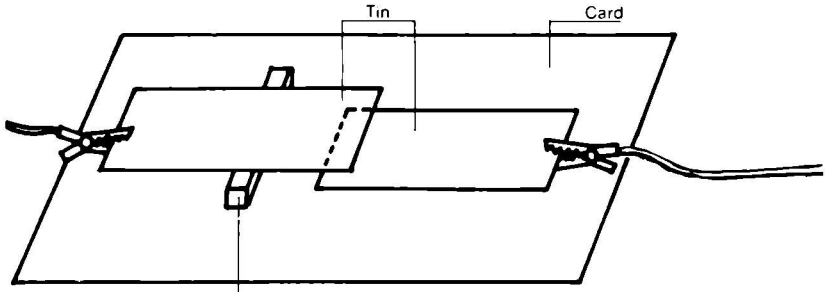
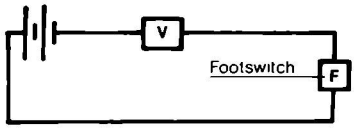
97 From our knowledge of experiment 96 we may now proceed to make a fire alarm circuit. It will be necessary to use two base units and two cells for this experiment. Assemble to one base a battery, Bi-metal strip and bracket as in the previous experiment. On the other base unit set up a vibrator (buzzer) unit as in experiment 88. Connect in series as in diagram. Warm the bi-metal strip with a match flame. You now know how a fire alarm unit works.



98 A simple burglar alarm can be easily constructed using a thin card size 6" x 4", two pieces of tin size 3" x $\frac{1}{2}$" and a piece of foam rubber size 1" x $\frac{1}{2}$". The diagram shows how to assemble the unit. The foot operated switch should be located under a doormat. Connect up the circuit as diagram, using either a bulb or vibrator to give the alarm. You are now prepared to detect the entry of an unwanted 'guest' who by stepping on the mat operates the switch and completes the circuit. In many instances a light is used as a means of warning as the use of a buzzer or bell might also warn the intruder.





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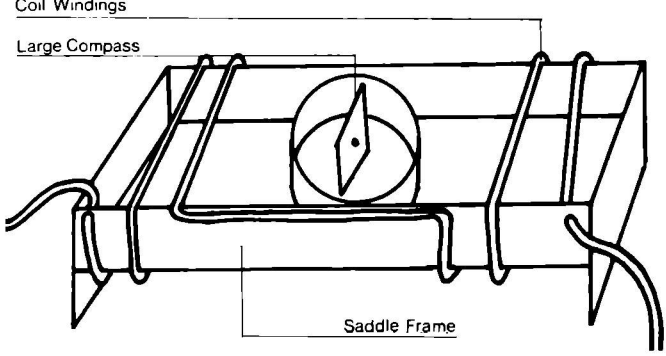
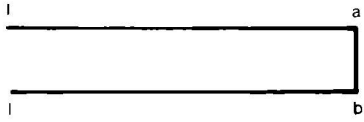
99 This is a further experiment in electro-magnetism and an approach to current measurement by use of a galvanometer. You will require the galvanometer saddle frame as illustrated in the diagram, large compass and length of PVC Wire. Place the compass in the centre of the saddle frame. Find the centre of the PVC wire and then bend the wire as shown in the diagram. Slip the corners A and B into the two slots in the saddle and proceed to wind two turns from the legs of the wire on the frame as shown in the diagram. Slip the remainder of the wire through the holes at the end and leave the long leads for connecting in the circuit.





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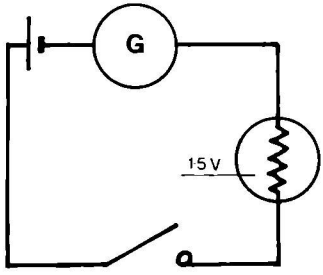
100 To use the galvanometer as a current detector, stand the saddle on the base unit and rotate until the needle is parallel to the windings i.e., at 90° to the axis of the coil.

Connect up the circuit as shown in the diagram and then switch on and note what occurs.



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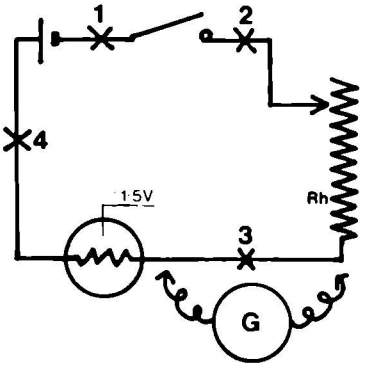
101 Repeat the experiment with the galvanometer at points 2, 3 & 4 in the circuit. Note the readings.

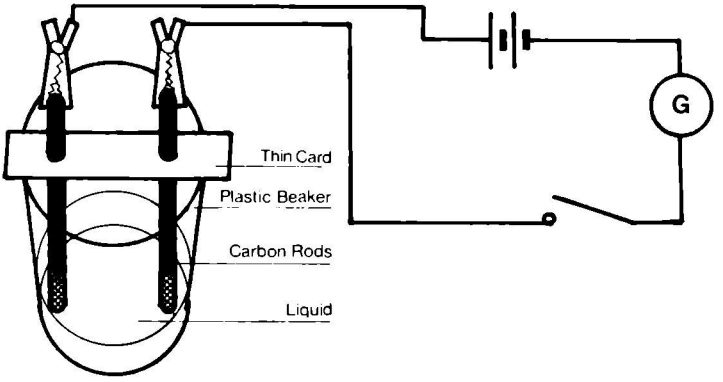


102 **Electro-Chemistry**

Do liquids conduct electricity? Obtain a small clear plastic beaker if possible, although an ice cream or yoghurt carton will do. Push two carbon rods through a piece of thin card. Place the card on top of the container as shown in diagram.

a) Pour into the container about $1\frac{1}{4}$'' depth of distilled water (tap water will do if distilled water is not available) Connect the carbon rods into the circuit shown in diagram. Switch on and observe carefully.

b) Pour out the distilled water and refill with a solution of Sodium Chloride (common salt). About half a teaspoonful of sodium chloride should be sufficient. What happens to the galvanometer.



103 Repeat experiment 102 but this time use a solution of copper sulphate again using half a teaspoonful. Switch on for several minutes. Switch off and remove the carbon rods. What do you notice about the carbon rods?

104 Repeat experiment 103 using The following solutions:-
a) vinegar
b) sugar
c) oil
(paraffin will do).

---

105 To electro plate a carbon rod set up the apparatus as in the previous experiment using a copper coin as an anode and the carbon rod as a cathode. Insert the rheostat in the circuit to control the current. If too high a current flows, the copper deposit is flaky. By trial and error you should obtain a bright metallic deposit.
NB You may also electro plate a knife blade, scissors, etc., in the same way although a thin film may be produced on iron and steel articles merely by dipping into copper sulphate solution without the use of the electro plating apparatus.

---

106 **Morse Code**
To study and operate the Morse code set up the circuit as shown in the diagram. The Morse Code is printed on the detachable cover which fits over the battery located in the base unit. A momentary depression of the key switch will make the lamp flash. A short flash represents a DOT and a longer flash represents a DASH in the code. A morse code message can be transmitted by a series of flashes or alternatively by incorporating a buzzer into the circuit instead of a bulb. The visual method is widely used by ships at sea as a means of communication with each other. The messages are transmitted by a lamp known as an Aldis lamp.
You must practice and memorize the code so that you are able to transmit a message which can be easily read. You will find it more fun if you ask a friend to learn the code with you. To operate the morse key place your index finger on the key and rest your thumb and and second finger on the base unit. Depress the key with your index finger and count one and immediately release the key. The single flash will represent a dot. To transmit a dash depress the key and count three before releasing the key. You should count one between the dots and dashes of a letter and count three between each letter. Finally count to five between each word.
You may wish to include numbers when transmitting a message. The code for number is as follows:-

1	•————	6	—••••
2	••———	7	——•••
3	•••——	8	———••
4	••••—	9	————•
5	•••••	0	—————

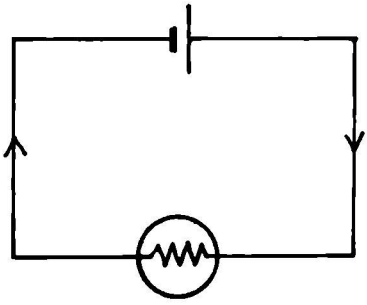
SOS •••——•••

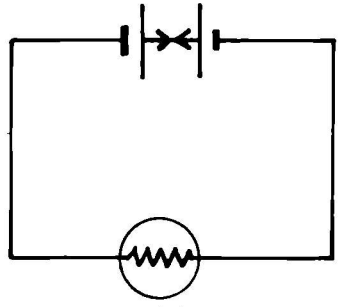
R84A With the bulb correctly rated for cell it should glow brightly.

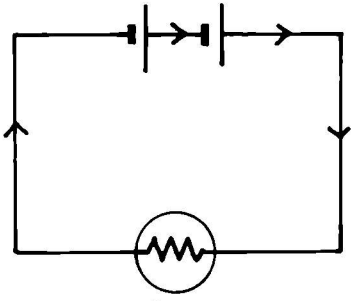
R84B Bulb is not so bright this time. Can we improve the brightness? Perhaps we require more cells.

R85 If both cells are new (equal strength) the bulb does not light. The cells happen to cancel each other out.

R86 Bulb glows brightly. The cells assist each other. The driving effect is usually measured in volts. A single cell is $1\frac{1}{2}$ volts two cells in series provide 3 volts of driving effect for the current.

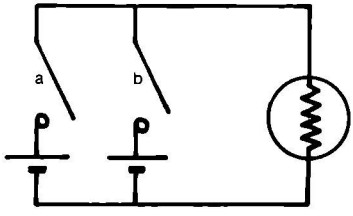






R87 The brightness for two cells in parallel is the same as for one cell across bulb. Hence voltage must be the same i.e., $1\frac{1}{2}$ volts to produce same current through bulb. Each cell contributes its own share of the current to the bulb. See arrows in diagram.

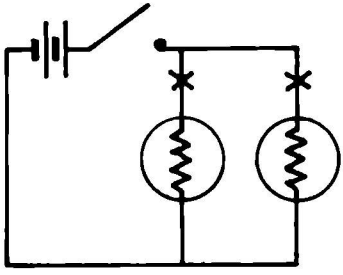
R88 This diagram shows how easy it is.



R89A With two bulbs in series the light is dimmer than with one bulb alone. They provide resistances which add up to reduce the current flow. This is equivalent to doubling the length of resistance wire in circuit.

R89B Removing one bulb does not affect the other. It still completes the circuit.

R90 This diagram shows where the switches should be in the circuit. The second switch may be wired in at either point X in the circuit. We are now getting close to the principles used in wiring up domestic lighting circuits.



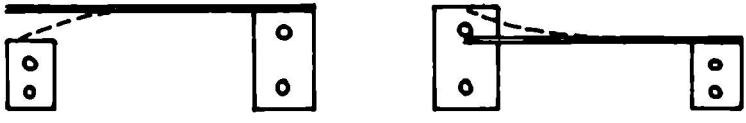
R92 The wire heats up. A lamp or an electric fire consists of a piece of high resistance wire through which a current is driven. It then gets hot.

R93 The wire glows and melts. It may catch fire hence the reason for the saucer. The circuit is now broken.

R94 With switch S closed both bulbs light but only dimly because the total resistance of 2 bulbs in series reduces the current flow. By closing Switch K the current has a low resistance path across one bulb which will go out while the second bulb glows more brightly. This shows that a short circuit may cause a heavy current to flow in a circuit. If this happens with mains electricity there is a danger of fire.

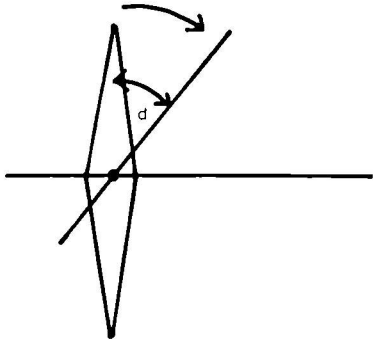
R95 When K is closed to shut out the bulb a heavy current flows momentarily, sufficient to melt the wire wool and break the circuit, so cutting off the current. To restore the current a new fuse must be installed. This principle is used in domestic circuits.

R96 The strip tends to bend because it is fabricated from two 'ply's' of metal which expand at different rates when heated. You should mount your strip so that when it bends on heating and makes contact with the other bracket, it may act as a switch in an electric circuit.



R97 The heat from the match flame makes the metal strip bend and make contact with the bracket, thereby completing the circuit and causing the buzzer to give the alarm. In buildings a sensitive bi-metal strip may be used to operate a water sprinkler system, an alarm bell or a lamp to warn of a rise in temperature in a building due perhaps to a fire.

R100 The bulb glows brightly and the galvanometer needle deflects, oscillates and comes to rest. A reasonable deflection is about 30° to 40°. If the deflection is greater you may reduce the number of turns on the saddle. If you wish to increase deflection you may wind extra turns to the saddle. Once the galvanometer is set in position do not disturb it when changing leads otherwise a series of readings will prove inaccurate.



R101 The galvanometer readings are all the same. This confirms that the current at all parts of a series circuit has the same strength.

R102A If distilled water is used no deflection of the galvanometer occurs. With tap water some current may be observed to flow.

R102B The galvanometer deflects and some bubbling may be observed in the solution. The salt solution conducts electricity and a chemical change occurs in the solution. This will be more obvious in the next experiment.
NB Wash out the container after each experiment.

R103 The galvanometer deflects, showing that an electric current will flow through copper sulphate solution. Bubbling in the solution occurs. When the rods are removed the one connected to the negative side of the battery is plated with copper showing that a chemical change has occured in the solution.

R104A Vinegar solution conducts electricity.

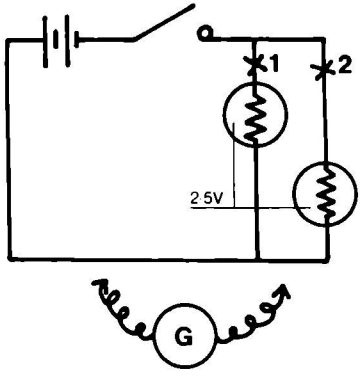
R104B No galvanometer deflection observed showing that sugar solution in non conducting.

R104C Paraffin does not conduct electricity.
To summarise, not all liquids conduct electricity. Solutions of some substances will act as conductors and these are called electrolytes. The two rods in the beaker which conduct electricity into and out of the electrolyte are called electrodes. The electrode at which current enters is called the anode and the one at which the current leaves is called the cathode.

Section **Experiments in this section and previous sections can be carried out with Electrical Lab 4.**

4

107 The galvanometer can now be used for the study of current in a parallel circuit. Set up the circuit as in diagram with two bulbs in parallel. Switch on and check that both bulbs light. Switch off and break the circuit at point marked X (1) in diagram and insert the galvanometer. Switch on and note the reading.
Now disconnect the galvanometer from the circuit. Break the circuit at the point marked X (2) in the diagram an reinsert the galvanometer. Switch on and note reading.



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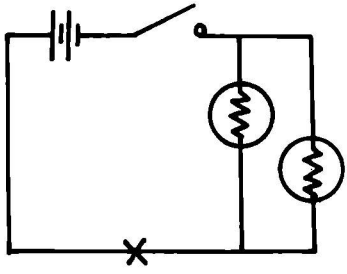
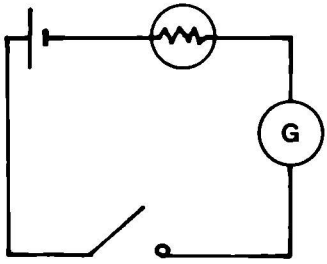
108 Set up the same circuit as in experiment 107 and without disturbing the galvanometer connect at point X in diagram and switch on. Note the reading How does it compare with previous readings.



109 a) Connect up the circuit as shown in diagram. Switch on and note the reading.
b) Now reverse the polarity of the cell, switch on and again note the reading.
c) Remove the bulb from the circuit and connect the galvanometer directly to the cell. Switch on and note the reading.



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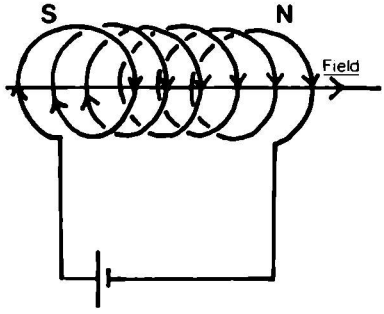
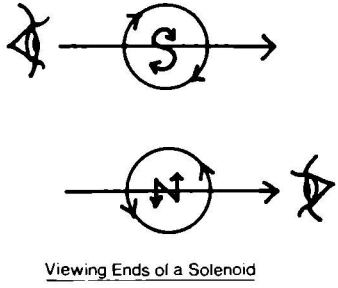
110 Repeat experiment 106. Look along the axis of the galvanometer coil and trace the current direction around the coil.





Viewing Ends of a Solenoid

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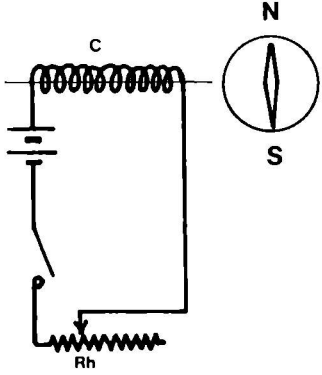
111 Using a length of enamelled wire wind a layer of turns around a pencil about 3" long and lay on an East-West line close to the galvanometer needle (out of its saddle frame)

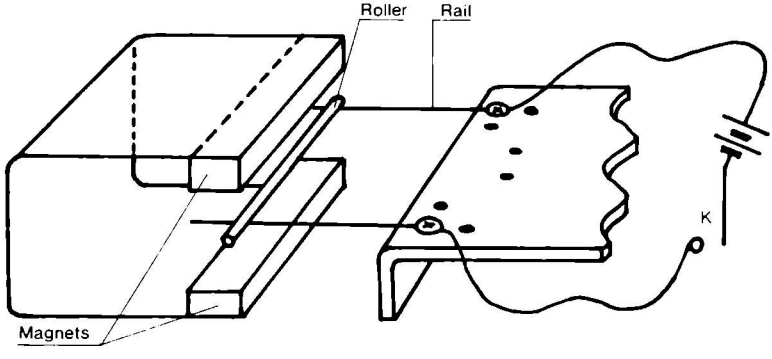
Connect up the circuit as shown in diagram. Press the key switch and adjust the rheostat to give a suitable small deflection of the compass needle.

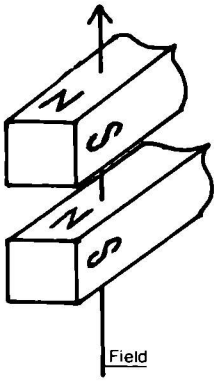


112 Without distrubing the set up of experiment 111 slip in the soft iron and switch on. Note the reading.

113 Pile another layer of turns on the solenoid but keep the core in place and current flow same as before. Press switch, note reading and compare.

114 The following four experiments deal with Electro Magnetic Catapult force. To set up the catapult experiments you will require to use the two large rectangular magnets in your set. You will note that these magnets are polarised across their flats. See diagram. When the magnets are attached to the yoke as in diagram in the field direction is vertical. Now strip 2" of PVC from connecting wire and loop around screws in base unit. Straighten the wire to form two guide rails. The roller is a stripped piece of connecting wire about 3" long and straightened out. Complete the circuit as shown in diagram and then press the key and watch the roller.



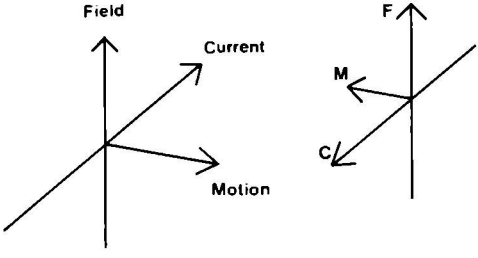


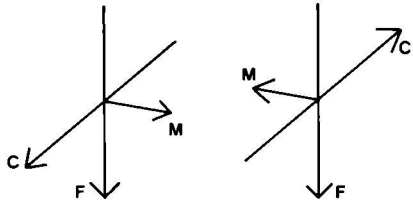
115 Repeat experiment 114 but this time reverse the current by changing the cell connections.

116 With the circuit set up as in the previous experiment slide the yoke and field magnets away from the rails. Rotate the yoke vertically so that the magnet positions are reversed and therefore the field direction is reversed but still vertical. Slide the yoke into former position and press the key. Note what happens.

117 Repeat the previous experiments and check Fleming's left hand motor rule against the diagram and using your left hand.
To summarize the experiments on Catapult force we note that a straight conductor carrying an electric current at right angles to a magnetic field experiences a force at right angles to itself and the field.

This rule is illustrated in the diagrams and is known as **'Fleming's left hand Motor Rule'.** Using the sketches hold the **F**orefinger of your left hand in the **F**ield direction and the se**C**ond finger in the direction of the current then the thu**M**b will indicate the direction of **M**otion all being held at right angles to each other.





How to construct a Model Moving Coil Galvanometer

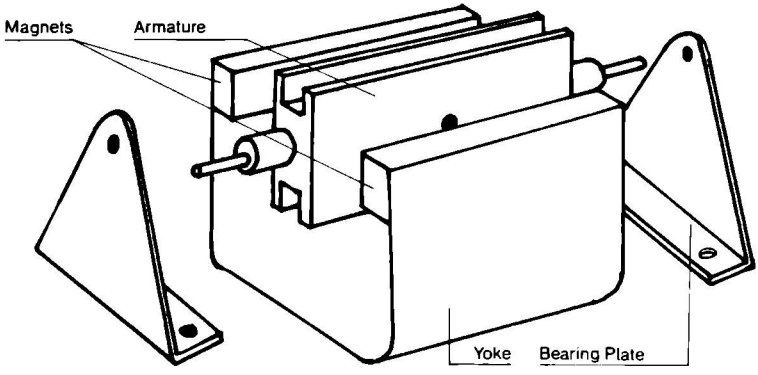
1 To wind the armature use approximately 5 ft. of connecting or enamelled wire and wind into grooves. Strip and free ends of the wire around the spindles at each end of the armature. See diagram.

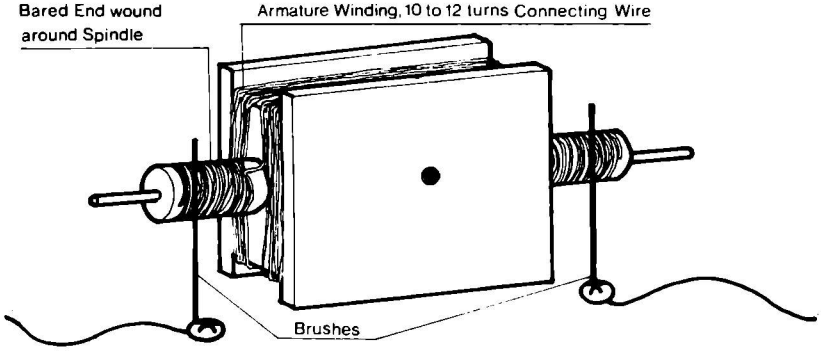
2 Place the yoke and magnets in position with North and South poles facing each other.

3 Slide the bearing plates onto the spindles at each end of the armature and secure the plates to the base unit. Before tightening the screws ensure that the armature rotates freely in the bearing plates.

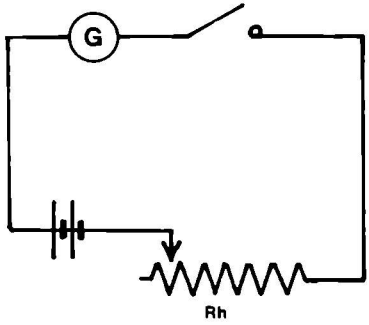
4 The brushes shown in diagram are made from two pieces of stripped PVC connecting wire and are screwed to the base unit so that they press very lightly on the bared ends of the armature winding.

5 On one flat face of the armature press a large piece of plasticine to act as a counter weight and secure a drinking straw with a small piece of plasticine to act as a pointer on the opposite face. See diagram.





119 With the galvanometer prepared in the previous experiment set up the circuit as shown in diagram. Press the key switch and adjust the rheostat to give a reasonable deflection of the pointer (about 20° to 30°). Adjustment of the counterweight will be necessary.



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120 Now adjust the rheostat to reduce or increase the current and note the changes of deflection. Reverse the battery connections and thereby reverse the current direction. What do you notice?

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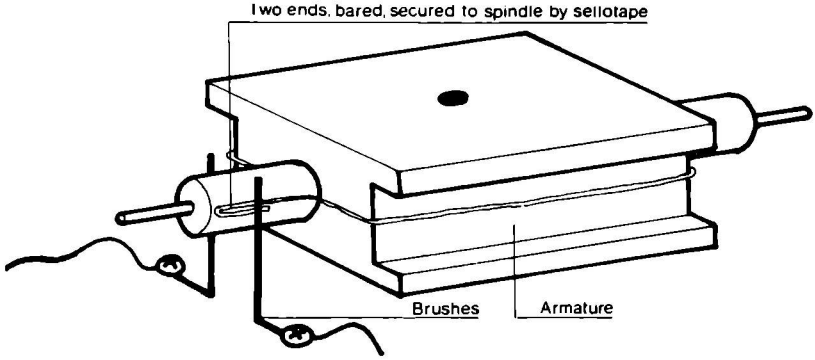
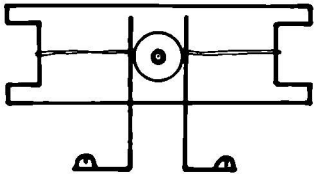
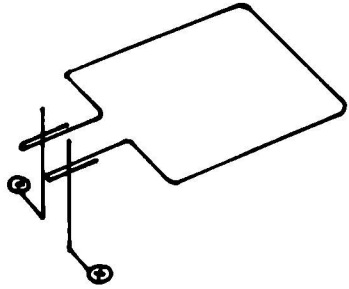
121 **How to Construct an Electric Motor**

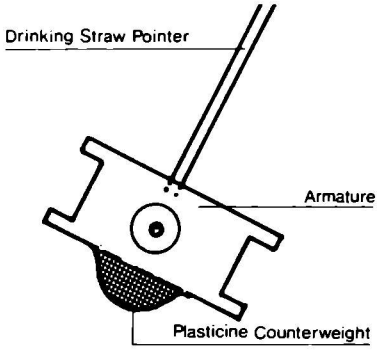
1 Modify the moving coil galvanometer constructed in experiment 118 by running both ends of the armature winding along opposite sides of the armature spindle as shown in diagram.
NB Doubling the ends of the wire as shown in diagram gives a better contact.
2 By connecting a $4\frac{1}{2}$ volt flashlamp battery to the brush terminals will make your motor continue to spin after you give it a start.
3 Take care to have good contacts between brushes and bared ends of armature winding but do not have too great a pressure between the two.
4 To make your motor operate really well increase the current by using two $4\frac{1}{2}$ volt batteries in series.
5 Do not run your motor for too long otherwise your batteries will soon run down.
6 The electric motor you have constructed is meant to be a model only for your fun and to illustrate the principles of simple motor design.


Two ends, bared, secured to spindle by sellotape
Brushes
Armature



End View



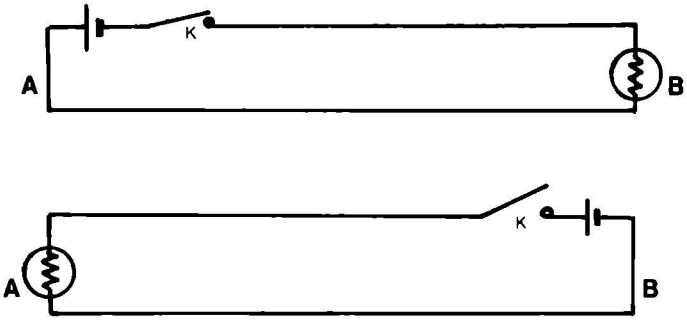

Drinking Straw Pointer
Armature
Plasticine Counterweight

122 Two Way Morse Code Communication

You will require to use two separate base units each with a morse cover, switch key, bulb and bulb holder. Place each unit on separate tables about 5 ft. apart.

Cut in half both of the long lengths of PVC wire in your set. Connect two wires so that the key switch of set A operates the bulb of set B. See diagram. Then connect two wires so that the key switch of set B operates set A. See diagram. The two operators should sit with their backs to each other so that communication is by lamp only using the morse code. You can have great fun sending morse code messages to a friend at night time. Set up two morse code units as in experiment 106. You will then be able to transmit messages from one house window to a friend in another house.

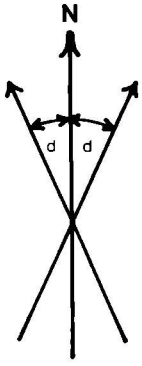
It would help if you made a simple shade to fit the bulb holder. One idea might be to use a 3" or 4" length of cardboard tube lined with aluminium foil.



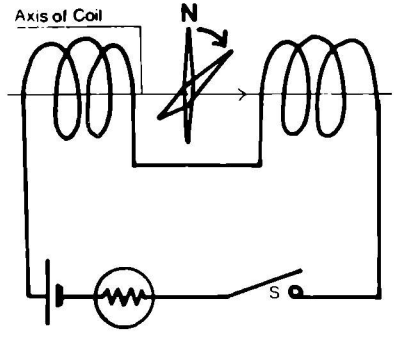
R107B The readings will be the same (good quality bulbs of the same rating should ensure a good result). Both bulbs must draw the same current.

R108 The galvanometer reading is much bigger so that a larger current flows in the rest of the circuit than flows through each bulb individually. We suspect that this current divides equally between the two bulbs but our galvanometer readings can not be used to prove this since doubling the current does not unfortunately double the deflection on this kind of galvanometer. It is interesting to look at the physics of the galvanometer.

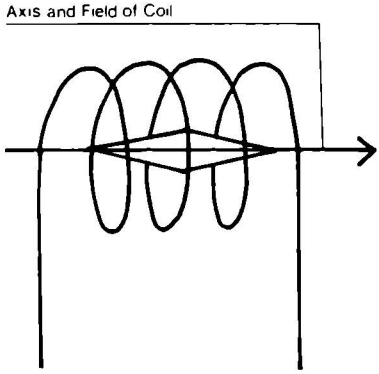
R109A The galvanometer deflection is reversed but has the same magnitude.



R109B The small current flowing through the bulb causes the magnetic needle to be pulled out of it N and S position towards the axis of the coil. The field direction due to the coil is E and W and is pulling the needle against the pull of the earth's field.



R109C With practically no resistance in the circuit a very large current flows through the galvanometer and the needle is pulled E and W along the coil axis due to a very powerful field.



R111 A small current energises the solenoid to give a weak magnetic field.

R112 A large deflection indicates a strong magnetic force due to core.

R113 A large needle deflection shows magnetic force is increased.
Our earlier experiments with a solenoid are now confirmed by more accurate measurement i.e. The magnetic strength of a solenoid is increased by:-
1 Increasing the strength of the electric current flowing through it.
2 Piling on more turns of wire.
3 Inserting a core of magnetic material. Electro magnets are used in wireless loud speakers, electric bells, buzzers, dynamos, etc.

R114 The roller is catapulted horizontally along the rails.

R115 The Roller is now catapulted in the opposite direction.

R116 Reversing the field direction reverses the direction of motion of the roller.

R117 This interesting experiment gives us a rule which helps in the design of electric motors and moving coil meters.

R120A Increasing the current increases deflection.
Decreasing the current decreases deflection.

R120B Reversing the current reverses the direction of deflection.

1

2

3 It occurs at least half an inch from the magnet.

4 It occurs at least a inch from the magnet

5 I noticed that when the magnet atracted the P. pins they all went

NOTES

NOTES

Printed in England by Lamport Gilbert Printers Ltd. Reading